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USE OF SKYLAB EREP DATA IN A SEA SURFACE TEMPERATURE EXPERIMENT

Quarterly Report

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FOREWORD

The research described herein, which was conducted by JRB Associates - a wholly owned subsidiary of Science Applications, Incorporated, was performed under NASA Contract NAS9-13277. This quarterly report covers the period from 17 February 1974 to 31 August 1974.

ABSTRACT

This report discusses the status of an experiment to utilize S191 spectrometer data acquired over ocean areas to assess the ability of spaceborne infrared multispectral sensing to function as a means of providing improved estimates of sea surface temperature over that obtainable with a single channel radiometric instrument. The data received from SL-2, SL-3 and SL-4 are summarized and critiqued. No specific results pertinent to the final experimental objectives are presented.

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INTRODUCTION

NASA is planning to launch an ocean observation satellite in the near future (Nimbus G) which will contain a two-channel infrared radiometric instrument capable of measuring the sea surface temperature to an accuracy of ± 1 Kelvin. The initial design of the instrument has been postulated but the spectral response of each of the two channels has not been finalized. It is expected that the results of EREP will influence the spectral response selection. An experiment of particular relevance consists of acquiring S191 infrared spectrometer data ($\sim$6 to $\sim$15 μm) over ocean areas for which the atmospheric and sea surface conditions and temperatures are known. The measured data will be compared with theoretical predictions and postulated radiometric techniques for measuring sea surface temperatures will be tested. The results are expected to provide an important input to the final selection of the spectral response of each of the two radiometric channels. The status of this experiment is described herein.

EXPERIMENT SUMMARY

At the termination of the three Skylab missions the data acquired for this particular experiment and scheduled for analysis were:

Mission	Date	EREP	Location	Support Data
SL-2	5 June 73	5	Gulf of Mexico-South of Houston	Aircraft
SL-2	11 June 73	8	Gulf of Mexico-South Central	Aircraft
SL-3	8 Aug. 73	16	Coastal Clouds-Oregon Coast	None

Mission	Date	EREP	Location	Support Data
SL-3	12 Sept. 73	36	Chesapeake Bay	Water Temp.
SL-3	15 Sept. 73	43	Coastal Clouds-California Coast	None
SL-3	17 Sept. 73	46	Chesapeake Bay	Water Temp.
SL-4	8 Jan. 74	78	Florida Staits	Aircraft, Ship, Meteorology
SL-4	9 Jan. 74	79	Near Bermuda	Aircraft
SL-4	21 Jan. 74	87	Gulf of Mexico-Caribbean	Aircraft

During the last quarter of 1973 the first set of data for each of the two SL-2 EREP passes, and each of the four SL-3 EREP passes were received. These data were carefully examined and certain irregularities were discovered which were attributed to data processing problems. Because of these problems none of the data could be used for analysis (see fourth quarterly report dated February 1974 for further discussion of these data).

Upon discovery of these problems JSC personnel made modifications to the processing software and began reprocessing the data. The planned reprocessing schedule was to reprocess SL-3 data first, then process SL-4 data, and lastly, reprocess SL-2 data. In accordance with this schedule we have received reprocessed data for all four SL-3 passes and data for SL-4 pass 79. Assuming the data were now ready for final analysis the data tapes from all four SL-3 missions were read and the data were carefully examined. Unfortunately, this examination revealed that the data still contained errors and data analysis would have to be further postponed until these errors were corrected.

DATA STATUS

Discussions with T. Barnett of JSC disclosed that the errors resulted from two problems, both related to instrument calibration. One is caused

by a drift in the responsivity of the spectrometer and the other results from off-band transmission of the filterwheel. Each of these problems have been examined by T. Barnett and it appears that the errors caused by a drift in the responsivity are correctable but the errors caused by off-band transmission of the filterwheel are not.

According to T. Barnett, the reasons for the uncorrectable nature of the off-band transmission problem are:

1) The spectral transmission characteristics of the spectrometer filterwheel are not accurately known;

2) The temperature of the dichroic beamsplitter is not accurately known;

3) The mirror reflectivity is not accurately known; and

4) The temperature of the mirror surfaces were different than ambient.

Because of this uncorrectable problem it may appear that all of the thermal S191 data are unuseable. Fortunately, this is not the case. If the aperature radiances have equivalent blackbody temperatures which are approximately those of the ambient calibration source, there are cancelling effects and the errors introduced are not significant. In general, when terrestrial surfaces can be viewed with little atmospheric interference this condition is satisfied. Therefore, for the spectral region between approximately 10 and 13 μm, and when viewing a warm terrestrial surface such as the ocean, the errors are acceptable. For each test site area scheduled for analysis for this investigation the proper conditions are satisfied, except for EREP passes 16 and 43. The test sites for these passes were cool coastal stratus clouds which yielded low radiance values. If the off-band transmission problem persists to be uncorrectable, all data for the cloud test sites will be unuseable.

The drift in the responsivity of the S191 spectrometer introduced significant errors into the data which have been estimated to be as large as 3%. For an effective blackbody temperature of 290 Kelvins this corresponds to 8.7 Kelvins. Fortunately this error is correctable and will be made to all data.

PLANNED EFFORTS

In accordance with the procedure suggested by T. Barnett the data for each mission will be corrected for drifts in sensor responsivity as follows.

1) The ambient calibration source radiance will be evaluated at the time of the post-pass autocalibration sequence using the measured values of the calibration source temperature.

2) The difference between the calculated ambient calibration source radiance and the radiance values measured during the post-pass autocalibration sequence will be evaluated at each wavelength throughout the spectral region of concern. This difference will represent the error accumulated between the pre-pass autocalibration sequence and the post-pass autocalibration sequence.

3) Assuming the error is a linear function of time, as measured from the time of the pre-pass calibration, each data value will be corrected according to:

$$L_C = L_m + \Delta L_D \frac{t - t_{pre}}{t_{post} - t_{pre}}$$

where

L_C is corrected radiance value

L_m is measured radiance value

ΔL_D is calculated radiance difference

t is the time at measurement

t_{pre} is the time at pre-pass calibration

t_{post} is the time at post-pass calibration

It is presently planned to apply this correction procedure to the data from all EREP passes (i. e., EREP passes 5, 8, 36, 46, 78, 79 and 87), except those for cloud test sites. In order to implement this procedure additional data will be required. In particular, a tabulation of the Post Auto Cal data are required for each pass, plus a tabulation of the calibration source temperature at the time of the Post Auto Cal. Upon receipt of these data responsivity drift corrections will be made and the originally planned analysis will commence.

Unfortunately, since all of the cloud data appear unuseable certain objectives of the experiment will be sacrificed. However, those aspects of the experiment which dealt with examining the potential of multispectral sensing in clear atmospheres to function as a means of obtaining improved estimates of sea surface temperature over that obtainable with a single channel instrument should be satisfied.